HUB AND BLADE ASSEMBLY FOR AN AGRICULTURAL COMBINE RESIDUE HANDLING SYSTEM

FIELD OF THE INVENTION

This invention relates generally to an agricultural combine. It relates particularly to a residue handling system for an agricultural combine.

BACKGROUND OF THE INVENTION

Agricultural combines are well-known machines for harvesting crop materials. They are available in various forms but all perform the basic functions of reaping crop materials from a field, separating grain from non-grain crop materials, and discarding the non-grain materials in the field.

A typical combine includes a crop harvesting or header assembly which reaps ripened crop plants from the crop field and a feeder assembly which feeds the crop materials to a threshing assembly. One type of combine incorporates a rotary threshing assembly. In such a combine, the crop materials are introduced to the front end of the rotary threshing assembly, which is oriented longitudinally, or axially, within the combine body. The crop materials are then threshed between a rotating rotor, which includes rasp bars along its exterior, and the inside of a rotor cylinder. Along the bottom of the rotor cylinder concaves are mounted that allow grain heads and other fine materials to pass through while retaining the crop stalks within the rotor cylinder.

The rotary threshing assembly includes mechanisms for feeding the crop materials rearwardly through the rotor assembly so that the crop stalks and other materials which do not pass through the concaves are discharged out the rear end of the assembly. The grain heads and other fine materials pass through the concaves onto a series of sieves that separate the grain from the unwanted fine materials. A cleaning fan directs air flow through the sieves to assist in the separation operation. After separation, the grain is conveyed to a grain bin through an auger system and the unwanted fine materials are discharged from the rear end of the sieves.

Modern farming practices require that the unwanted crop stalks be chopped up, mixed with fine materials, and evenly spread across the crop field. This is especially true with no-till farming, but is also important for more traditional farming techniques.

The demand for greater productivity has resulted in larger header assemblies, which harvest wider swaths in the crop field, and increased travelling speeds of the combine across the crop field. This has led to a need for more effective distribution systems for the non-grain crop materials.

A common type of non-grain or residue distribution system includes a residue chopper. The residue chopper is typically located in the rear of the combine body. Some types of residue choppers receive and distribute only crop stalks from the rotor assembly. Other types receive and distribute both crop stalks and fine materials from the sieves.

The residue chopper is oriented transversely of the combine and includes a plurality of flail blades which chop and mix the crop materials. The flail blades are pivotally connected to supports on a rotating hub. Normally, two flail blades are attached to each support, with one on each side of the support. In most prior art systems the two flail blades are spaced from the mounting support with spacer bushings.

However, with such a construction, the mounting flange can become weak from continuously applied stresses and eventually break, causing unwanted downtime and repair costs. Additionally, use of these spacer bushings does not permit accurate positioning of the flail blades.

Air flow through the residue chopper greatly influences the effectiveness of the chopper in mixing the crop materials and distributing them from the rear of the combine. Vanes located at the exit of the residue chopper sweep in an outward direction to spread the crop materials across the crop field. Optimally, the crop materials will be discharged evenly in a swath which is the same width as the combine header assembly. However, because combine header assemblies can be as wide as thirty feet and more, the crop materials must exit the residue chopper at a high velocity in order to be directed across a wide swath. This necessitates a large volume of air flow through the residue chopper to achieve the desired exit velocity.

In residue choppers which receive both crop materials from the threshing assembly cylinder and fine materials from the sieves, it is a common practice to direct the cleaning fan air through the residue chopper. In this arrangement, the residue chopper housing becomes the primary path for the cleaning air, and the cleaning fan becomes the primary source of air flow through the residue chopper. The design and shape of the residue chopper's flail blades is important in ensuring adequate air flow through the chopper. Some known flail blades inhibit air flow through the residue chopper and actually create back pressure that partially prevents the cleaning fan air flow from entering the chopper. This not only adversely affects exit velocity of the crop materials but also reduces the effectiveness of the cleaning fan in separating the grain from the non-grain fine and light materials.

BRIEF SUMMARY OF THE INVENTION

It is a primary object of the invention to provide an improved residue chopper in a rotary combine.

It is also an object of the invention to provide an improved flail blade which assists the cleaning fan in moving air through the residue chopper.

It is another object to provide an improved flail blade which increases air flow through a residue chopper.

It is still another object to provide a flail blade which is configured intermediate its ends so that the front surface of the blade is inclined from the direction of blade travel in the chopper.

It is a further object of the invention to provide a mounting arrangement for the flail blades on a hub which includes a hollow mounting support having a width equal to the desired space between the inner ends of mated flail blades.

It is still a further object to provide a flail blade mounting arrangement which better resists fatigue stresses while providing more accurate flail blade positioning.

It is yet a further object to provide an improved hub and blade assembly in a residue chopper for a rotary combine.

It is yet another object to provide an improved hub and flail blade assembly including a pattern of flail blades which provides optimum residue distribution.

According to the invention, each flail blade is pivotally connected to a rotatable hub in a hub and blade assembly. An inner portion of the flail blade is flat and lies in a plane perpendicular to the axis of rotation of the hub. An outer portion of the blade is also flat, but is inclined from that plane. Thus, the front surface of the outer portion of the

blade is inclined at an angle to the plane of rotation of the blade. As the blade rotates during operation of the chopper, this angled front surface increases the flow of air through the chopper housing by moving air ahead of it.

In a mated blade arrangement, two blades are attached to a single mounting support. In a first form of mated blade arrangement, the outer portions of the blades are angled in opposite directions so that the leading edges of the outer portions of two flail blades are closer to each other than the trailing edges. What amounts to a V-shaped pocket is formed behind the blades as they rotate. In a second form of mated blade arrangement, the trailing edges of the outer portions of mated blades are closer to each other than the trailing edges, creating a V-shaped pocket in front of the blades. In a third form of mated blade arrangement, the leading and trailing edges are equidistant from each other. A fixed knife attached to the housing passes between the leading edges of the mated blades when the hub rotates, producing a scissors cutting action to chop-up crop materials.

According to the invention, different forms of mated blade arrangements may be mounted on the same hub to create a pattern in the hub and blade assembly which produces a desired pattern of residue blown from the chopper. A hub and blade assembly may be effectively divided into three sections: a center section having the first and/or second form of blade arrangements thereon; a left section having the third form of blade arrangements thereon with the outer blade portions inclined so as to direct residue to the left as well as rearwardly; and, a right section having the third form of blade arrangements thereon with outer blade portions inclined so as to direct residue to the right as well as rearwardly.

The mounting support for each blade or mated pair of blades includes a rectangular cross-section post. The mounting support post has front, back, and side walls. The width of the post is substantially the same as the desired distance between the parallel inner portions of two mated flail blades, Therefore, the side surfaces of the inner portions on the flail blades directly contact the side walls of the mounting support post, without the need for spacer bushings. The flail blades can be pivotally mounted on the support post using only three mounting elements and a wrench.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

The invention, including its construction and method of operation, is illustrated more or less diagrammatically in the drawings, in which:

FIG. **1** is a side elevational view of a portion of a rotary agricultural combine, with parts of the combine removed to display internal components;

FIG. **2** is a vertical sectional view through a straw chopper embodying features of the invention;

FIG. **3** is a perspective view of a portion of the hub and blade assembly in the straw chopper of FIG. **2**;

FIG. **4** is a side elevational view of the hub and blade assembly the straw chopper of FIG. **2** with parts removed;

FIG. **5** is front elevational view of the hub and blade assembly seen in FIG. **4**;

FIG. **6** is an exploded view of the blade mounting elements for the blades seen in FIGS. **4** and **5**;

FIG. **7** is a front elevational view of a second form of hub and blade assembly for the straw chopper;

FIG. **8** is a front elevational view of a third form of hub and blade assembly for the straw chopper; and

FIG. **9** is a top plan view of a modified hub and blade assembly for the straw chopper of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings, and particularly to FIG. **1**, a portion of a rotary combine is shown generally at **10**. The combine portion **10** includes a feeder assembly **20** and a rotary threshing assembly **22**. The rotary threshing assembly **22** includes a rotor **26** and a rotor housing **28**. Crop materials travel rearwardly through the rotary threshing assembly **22** and are threshed by a series of threshing elements attached to the exterior of the rotor **26**.

Along the bottom side of the rotor housing **28** are perforated concaves **30** which allow grain heads and other fine materials to pass through, and out of, the rotary threshing assembly **22**. Larger material pieces such as crop stalks continue rearwardly through and are discharged out the rear end of the rotary threshing assembly **22**.

The grain heads and other fine materials are directed to a series of sieves **32**. A drive mechanism (not shown) effects a constant back and forth motion between the sieves **32**. As the crop materials pass through the sieves **32**, they further separate the grain from the unwanted chaff and fine and light materials. A cleaning fan **34** located forward of the sieves **32** blows air rearwardly through the sieves, thus helping to separate the grain from the fine and light materials. The cleaning fan **34** air also drives the unwanted fine and light materials out the rear end of the sieves **32**.

The distribution of unwanted crop materials onto the cleared field as the combine **10** travels across the field is effected by a residue chopper **40** embodying features of he invention. The chopper **40** chops the crop stalks into a finer residue material, mixes the chopped crop stalks with the chaff fine materials, and distributes the mixed residue evenly across the crop field. The residue chopper **40** is oriented transversely of the combine to the rear of the threshing assembly **22**.

Referring now to FIG. **2**, the residue chopper **40** includes housing **42** mounted in the combine body **12** and elongated transversely of the body. The housing **42** encloses a rotatable hub and blade assembly **49**, including a hub **48** to which flail blades **50** are pivotally attached, preferably in mated pairs. The hub and blade assembly **49** is viewed from one end of FIG. **2**, which shows it rotating in a counter-clockwise direction.

The housing **42** has front entrance **44** through which both crop stalks and chaff fine materials enter. It also has a rear exit **46** where chopped materials exit. To aid in spreading the exiting crop materials evenly across the field, vanes **47** are attached to the rear end of the combine body **12** near the rear exit **46**. The vanes **47** are angled outwardly so that the crop materials which exit the system **40** are redirected to cover a wide swath pattern. Optimally, the width of the swath pattern is equal to the width of the header assembly (not shown) attached to the feeder assembly **20** at the front of the combine.

To spread the crop materials over a swath of this width, the crop materials have to contact the vanes **47** at a high velocity. In order to achieve this high velocity, a large amount of air flow must be driven at a high speed through the housing **42**. The system **40** of the present invention accelerates the stream of air received from the cleaning fan **34** so as to produce an air flow speed of up to sixty miles per hour at the exit **46**.

Referring now to FIG. **3**, in the hub assembly **49** a plurality of flail blades **50** are pivotally attached to a hub **48**

in pairs **51**, arranged in a row spaced along the length of the hub **48**. In turn, four such rows are displaced 90° from each other around the hub **48**. Drive means (not shown), which are well known to those skilled in the art, rotate the assembly **49**.

Referring additionally to FIGS. **4** and **5**, each flail blade **50** includes a flat inner mounting portion **54** lying in the plane of blade rotation, which is transverse to the axis of the hub **48** ("inner" and "outer" being relative to the connection of the flail blade with the mounting point with the mounting post). The outer portion **56** of the flail blade **50** is angled away from the plane of rotation of the blade. The blades **50** are pivotally connected to the hub **48** in a manner hereinafter discussed.

A preferred method of manufacturing the flail blade **50** is by bending a single piece of metal so that an intermediate portion **58** is bent in a smooth transition between the outer portion **56** and the inner portion **54**. In the illustrated blade, **50**, the outer portion **56** is flat, both longitudinally and transversely. Therefore, as the hub **48** rotates each radial line along its forward surface **60** travels along a different plane.

Although the invention envisions employing a variety of blade **50** angles, a preferred configuration has a flat outer portion **56** which is angled five degrees from the plane of blade rotation so that its projected frontal area is twelve millimeters wide. In an alternative configuration, the flat outer portion **56** is angled thirty-five degrees from the plane of blade rotation so that its projected frontal area is twenty-four millimeters wide. The specific angle of the outer portion **56** in a flail blade can be tailored to optimize the cutting action, i.e. fine or coarse, and the effect on exiting air flow velocity of the system **40**.

The flail blades **50** are preferably attached to the hub **48** in mated pairs **51**, as has been pointed out. In the arrangement seen in FIGS. **3–5**, the leading edges **62** of the outer portions **56** on mated flail blades are relatively close to each other. The trailing edges **64** of the outer portions **56** on the mated blades, on the other hand, are relatively further from each other. A V-shape pocket is formed between, and behind, the outer portions **56** of the mated blades.

As the hub **48** rotates, the forward surfaces **60** of the outer portions **56** compress the air in front of the blades **50**, driving air forward. Also, a pressure drop is created in the pocket formed behind the rear surfaces **61** of the outer portions **56** of each pair of blades **50**, causing the rotating blades to draw air from the rear.

Referring to FIG. **2**, attached to the base of the housing **42**, in fixed relationship, are a series of knives **43** (only one shown). The knives **43** extend upwardly, inside the housing **42**, between mated pairs of flail blades **50**. A scissor-like cutting action results as each flail blade **50** passes by a knife **43**. The cutting action chops the crop materials into a finer residue.

The knife blades **43** are all mounted in one, downwardly removable cassette (not shown). The number of knife blades **43**, and their placement, can then be easily changed, based on the angle and width of the flail blades **50**, in order to achieve a variety of fine or coarse cutting actions.

Preferably, the leading edge **62** of each flail blade **50** is sharpened, as at **63**, to enhance the scissor action. This is accomplished by relieving the leading edge **62** to a surface that it lies in the plane of blade **50** rotation, or is angled from this plane, so that this surface actually undercuts the forward surface **60**.

The blade **50** mounting support includes a mounting post **72** for each pair of blades **50** fixed to the hub **48**. Each post **72** comprises a rectangular cross-section tube extending radially away from the hub **48**. Each tube includes front and back walls **74** and **75**, and left and right side walls **76** and **77**. The outside width of the tube in each mounting post **72** is substantially the same as the desired distance between the mounting surfaces **52** of a mated pair of flail blades **50**. Thus, the mounting surfaces **52** of the flail blades **50** seat flush against the exterior surfaces of the side walls **76** and **77**.

Referring to FIG. **6**, as well as FIG. **5**, the mated pair of blades **50** are pivotally mounted on the support post **72** with a hollow pin **78**. The pin **78** extends through the inner portions **54** of the flail blades **50** and the mounting support side walls **76** and **77**. The pin **78** has a cap **79** at one end and an internally threaded bore **80** extending into the other end. A bolt **81** having a head **82** and a threaded shaft **83** is inserted through a washer **84** into the bore **80**. The threaded shaft **83** is received in the threaded bore **80**. The bolt **81** can easily be tightened with a wrench, acting on the head **82**.

In order to provide maximum contact area between the flail blade **50** and the mounting support **72**, and to allow pivoting clearance between the inner portion **54** of the flail blade and the hub **48**, the innermost edge of the flail blade is formed in a segmentally circular shape around the pivot axis of the bolt **78**. This is best seen in FIG. **4**.

The flail blades **50** are more accurately positioned in the present invention because spacer bushings, which are commonly used in prior art systems, are not required. Additionally, a greater area of surface contact and, thus, support is possible between the flail blade mounting surface and the mounting support side walls **76** and **77**. Because the flail blades are positioned more accurately, a more effective scissor action is made possible because each knife **43** may be positioned closer to the spaced flail blades **50** than is possible with prior art mounting systems. The tubular configuration of the mounting post **72** is also stronger than the simple tang mounts prevalent in the prior art. Therefore, the mounting post **72** can better resist fatigue stresses, stresses that cause tang mounts to break.

In the first form of blade assembly **49** which has been described, the leading edges **62** of mated blades **50** are relatively close to each other while the trailing edges **64** are relatively further apart. In a second form of blade assembly, seen in FIG. **7**, just the opposite is true. In this form, the trailing edges **164** of mated blades **150** are relatively close to each other while the leading edges **162** are relatively further apart.

In a third form of hub and blade assembly **249** embodying features of the present invention, as seen in FIG. **8**, the leading edges **262** and trailing edges **264** of the mated blades **250** are equidistant from each other. The outer portions **256** of each blade **250** in a mated pair are angled at anywhere between five degrees and thirty-five degrees from a plane transverse to the axis of rotation of the hub **248**.

Referring now to FIG. **9**, another hub and blade assembly **349** embodying features of the invention is illustrated. The assembly **349** utilizes a combination of blade forms which produce a particularly advantageous result; serving both to enhance air flow through the chopper housing and the spreading of exiting crop materials across the field.

As seen in FIG. **9**, the hub and blade assembly **349** includes a hub **348**. Six rows of mated pairs of blades **350** are mounted on the hub **348** (60° displaced from each other). Each row contains five evenly spaced pairs **351** of blades **350**.

Each row of blade pairs **351** also includes three different blade **350** arrangements, **350A**, **350B** and **350C**. In FIG. **9** in